

Intracranial aneurysm encasement

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As improvements in neurosurgical techniques applied to intracranial surgery for prevention of bleeding from arterial saccular aneurysms are more widely appreciated, understood, and utilized by more neurosurgeons throughout the world, the particular problems encountered in each patient with an intracranial aneurysm become more readily solved. Better general pre-operative evaluation and care, including total intracranial dynamic vascular contrast studies, the pre-operative, operative, and post-operative use of corticosteroids to combat cerebral oedema, and the effects of operative trauma, the utilization of controlled respiration neuro-anaesthetic techniques, the improvement in operative field visibility by utilizing magnification and improved lighting techniques, along with the use of a variety of special instruments specifically designed for intracranial aneurysm surgery, have all aided in improving the over-all operative results. When the surgeon finds he can safely apply a clip or ligature to the neck of the aneurysm and not impair vessel patency, he can thus eliminate the aneurysm from the vascular stream and prevent possible fatal haemorrhage, yet maintain continuity of normal blood flow to the cerebral tissues distally. Intentional sacrifice of a vessel should be avoided where possible.

There are circumstances, however, that preclude safe, elective aneurysmal neck occlusion. Specific situations all too frequently encountered include the following:

(1) The aneurysm arising from the middle cerebral artery complex with efferent vessels exiting from the walls or dome of the aneurysm, whereby obliteration of the aneurysm neck would interfere with some distal blood flow.

(2) The aneurysm arising from the anterior communicating artery complex, rather than solely from the anterior communicating artery itself, when present, such that attempted neck clipping could cause impairment of distal anterior cerebral blood flow.

(3) The aneurysm which arises from an unequal or asymmetrical first portion (A-1) of the anterior

cerebral artery whereby a 'trap' procedure would significantly impair either or both of the more distal anterior cerebral arteries' blood flow as well as the 'trapped' anterior cerebral perforating branches.

(4) The aneurysm the neck of which is too broad for a conventional clip and which, when a ligature is tied snugly, would cause impingement upon the parent vessel lumen due to distortion, kinking, or indentation by the mass within the ligature.

There are other specific situations that individual neurosurgeons with experience can also cite as examples peculiar to a given patient which could make occlusion of an aneurysm neck relatively unsafe or unwise. These problems are becoming more evident in the vertebral-basilar artery circulatory distribution as well.

An additional problem being recognized more frequently and accurately as the result of the use of operative and post-operative angiography (Drake and Vanderlinden, 1967), is that of the aneurysm the neck and dome of which were thought to have been successfully obliterated surgically, but where a portion of the weak aneurysm-vessel junction area can be shown to be still in direct continuity with the passing blood stream (Figs. 1 and 2). It was from this weakened junctional area that the aneurysm originally arose (Sahs, 1966). This situation is not always immediately apparent. At a later angiography or on necropsy examination, it has been noted that a clip or ligature is no longer in absolute juxtaposition to the parent vessel, but has been displaced and is now part of the dome or wall of what is essentially a new aneurysm formation, having arisen at the remaining weakened site in the vessel wall (Hayes, 1967; Sahs, 1966).

These varied situations do not afford a safe or a total permanent isolation of the aneurysm from the main arterial stream to prevent further possible intracranial haemorrhage. As a result, additional methods for solving these problems have been sought.

It has been apparent to some (Dutton, 1956;

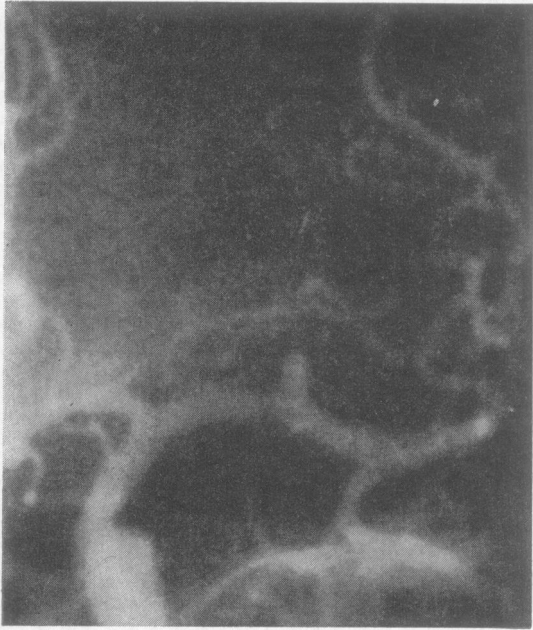


FIG. 1. Pre-operative angiogram showing aneurysm arising from middle cerebral artery approximately 1 cm from its origin.

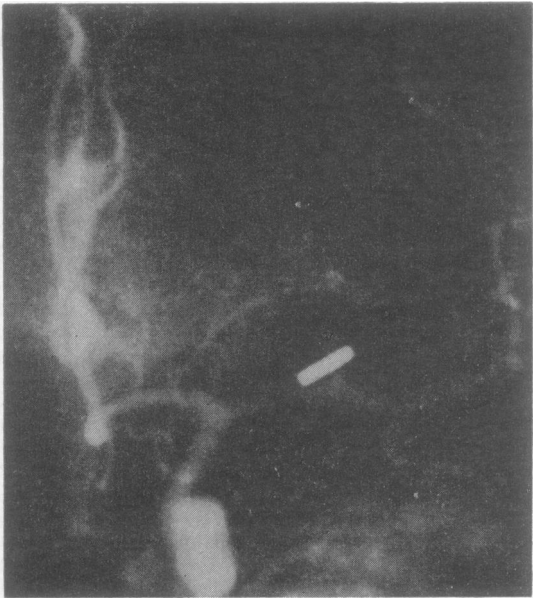


FIG. 2. Post-operative angiogram which reveals only partial aneurysm occlusion due to improper application or migration of clip.

Silverstone and Ronis, 1958; Dutton, 1959; Hayes and Leaver, 1966), that the encasing or investing of the non-clippable aneurysm or aneurysm complex, and also of the successfully clipped or ligated aneurysm with a material to prevent rebleeding or reformation of the aneurysm would add significantly to the immediate and long-term results of corrective and curative intracranial aneurysm surgery.

A major step has been taken in this direction by the use of an easily applied material which completely encases the aneurysm complex, rapidly solidifies, and prevents the possibility of haemorrhage yet maintains parent vessel continuity (Dutton, 1956, 1959; Hayes and Leaver, 1966). This thus affords the aneurysm and its associated afferent and efferent vessels a reinforced exterior wall, preventing either rupture of the aneurysm or regrowth of the aneurysm from its weakened site of origin.

METHOD

A somewhat detailed operative approach is described to emphasize simplicity yet completeness.

Utilizing controlled respiration ('hyperventilation') endotracheal general anaesthesia (Hayes and Slocum, 1962) with an increase of 30-50% above estimated normal minute volume¹, a small modified Dandy frontotemporal osteoplastic craniotomy is performed, being carried well down along the lateral sphenoid ridge, and the dura opened as it crosses the sylvian fissure anterolaterally. The prechiasmatic cistern is then approached by gently retracting the frontal lobe along the sphenoid ridge, entered and cisternal fluid thoroughly aspirated. If the aneurysm is located at or near the anterior communicating region cisternal fluid is removed from between the internal carotid artery and the optic nerve, rather than from the pre-chiasmatic cistern, to avoid possible rupture of the aneurysm. The aspiration of this cisternal fluid is usually all that is necessary to gain excellent operative exposure when using the controlled respiration technique. In cases with significant hydrocephalus, a lateral ventricular tap can be performed through the operative area. The bridging veins from the temporal tip to the sphenoparietal sinus are identified, coagulated, and divided when indicated—that is, when the temporal lobe is to be retracted. The internal carotid artery is then identified and it or its appropriate branch is followed out to the aneurysm location, thus always having proximal vessel control available. When the aneurysm is from the basilar artery region, the internal carotid artery usually need not be dissected free.

When the aneurysm complex (including afferent and efferent arterial vessels) is identified it is then carefully, but completely, separated from its surrounding cerebral tissues. In areas such as the anterior or posterior perforated substance, or where the aneurysm is particularly

¹The Radford Nomogram (Radford, Ferris, and Kriete, 1954), is used to calculate this percentage increase.

long or may be under the tentorial edge—as may occur when arising from the area of junction of the internal carotid and posterior communicating arteries—application of a clip or ligature to the completely visualized neck may be performed before or in lieu of further dissection of the dome. This can then be followed by amputation of the aneurysm dome from its neck, or its aspiration by needle and syringe, thus collapsing the dome. When the entire aneurysm complex or its residual is then free of its investing tissues, the surrounding area is kept as dry as possible, using suction to prevent the fast-setting methyl methacrylate¹ from being floated away during its application. If the parent vessel appears to be in spasm, topical application of a phenolamine mesylate¹ soaked cotton patty for approximately five minutes has been found to be advantageous in reducing the spasm.

Achieving optimal exposure of the aneurysm complex, the methacrylate liquid and powder are then mixed in approximately a 1:2 ratio and stirred until a consistency similar to that of thick syrup is attained. Using a small medicine dropper, a few ml. of the mixed methacrylate are injected beneath and behind the aneurysm complex, and then additional methacrylate is applied by the dropper to the sides and presenting surface of the entire aneurysm complex, again noting that the immediate afferent and efferent vessels as well as the entire aneurysm must be immersed in and covered by the methacrylate. The hardening time is approximately two to three minutes *in situ*. The heat of polymerization² (up to 115° F if not irrigated) can be felt in a small ball of the acrylic the surgeon may wish to roll between his gloved fingers (Dutton, 1959). When he feels either an increase in warmth or a hardening of this ball, the operative field is then irrigated continuously for five minutes with room-temperature sterile saline to dissipate the heat of reaction. It should be noted that retracting spatulae, cotton patties and other instruments should be removed from the operative field before the hardening of the methacrylate. Inclusion of ligatures, clips, gelatin foam, muscle stamps, or fine mesh gauze applied to the immediate area of the aneurysm complex is totally acceptable. A routine craniotomy closure is then performed. Antibiotics are not routinely administered prophylactically.

If during dissection the aneurysm should rupture inadvertently, appropriate clipping of the dome and/or neck can be performed if necessary, but if the parent vessel's or an efferent vessel's patency might be jeopardized, the application of a small muscle stamp and gentle pressure will usually be effective in controlling the bleeding. The dissection can then be continued and the adherent muscle stamp tamponade will be included in the encasement procedure.

An attempt is usually made not to apply the methacrylate directly to the optic nerve or other cranial nerves, but at times this has not been found to be either possible or practical. There have been no recognized instances where optic nerve damage has been clinically apparent

or of other cranial nerves which the methacrylate may have either touched or even encompassed.

DISCUSSION

Since 1957, when Hayes began using methyl methacrylate to encase intracranial aneurysms at Walter Reed General Hospital, 63 patients with 78 aneurysms have had definitive encasement procedures on 72 of these aneurysms. The author has treated similarly 30 additional aneurysms in 22 patients while at the U.S. Army Hospitals in Landstuhl and Frankfurt, Germany. A total of 85 patients have had 102 aneurysms encased in fast setting methyl methacrylate. The first 40 patients have been reported previously by Hayes and Leaver (1966). Table I shows the location of the various

TABLE I

LOCATION OF ANEURYSMS ENCASED

Middle cerebral artery	45
Internal carotid artery	29
Anterior communicating artery	13
Bifurcation internal carotid artery	7
Proximal anterior cerebral artery	3
Distal anterior cerebral artery	3
Vertebral-basilar artery	2
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aneurysms encased. It is of interest that 20 of these 85 patients (23.5%) had multiple aneurysms, two patients had four. There were eight deaths in the post-operative period, a surgical mortality of 9.4%.

When treating surgically aneurysms of the middle cerebral artery and anterior communicating-anterior cerebral artery complex, maintaining a normal vascular flow while preventing rebleeding is best achieved by the encasement procedure when this is possible.

The only known post-operative haemorrhages from 'encased' aneurysm areas have occurred as a result of incomplete encasement. There have been two such cases and both were at the trifurcation of the middle cerebral artery. In one the rebleeding caused death and in the other an intracerebral haematoma with resultant permanent hemiplegia. In both cases the operative areas were directly re-examined and incomplete encasement noted, both encasement defects being on the most inferior surface. No other cases of bleeding from the encased aneurysm complexes have occurred.

In two instances where the author has re-explored the operative field where methacrylate had been applied previously—one case as the result of rebleeding as cited above, and the second case where a surgeon at another hospital applied methacrylate to a contiguous area, but not to the actual aneurysm

¹Aneuroplasty (Codman and Shurtleff, Inc., Randolph, Massachusetts, U.S.A.)

²Regitine (Ciba Pharmaceutical Co., Summit, New Jersey, U.S.A.)

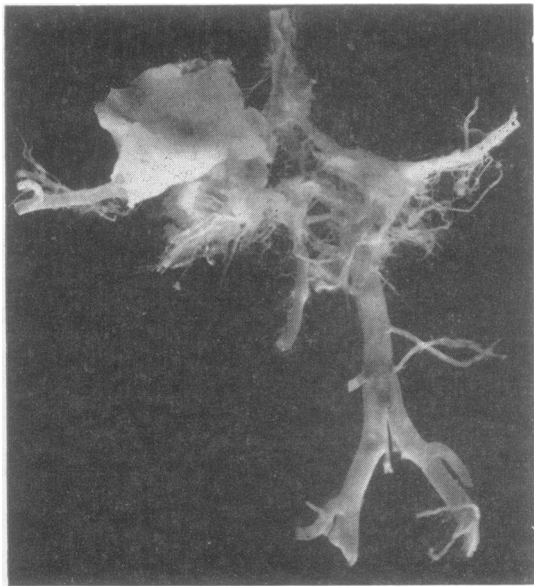


FIG. 3. Photograph of an encased internal carotid artery aneurysm complex showing the general relationship to the entire carotid-vertebral-basilar tree.

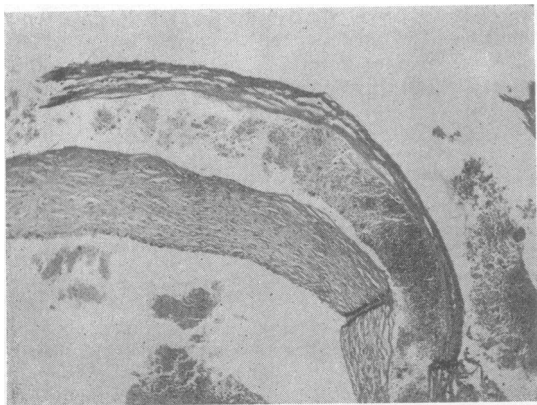


FIG. 4. Wall of aneurysm shown in Fig. 3 with plastic removed showing minimal surface response.

complex—it was apparent that there was no adherence of the methacrylate to the surrounding cerebral tissue, and no gross evidence of an increased glial reaction greater than would have been anticipated from the previous operative dissection. Dutton (1959) has also noted this previously.

There have been no necropsy examinations where pathological examination of the encased aneurysm complex could be performed at a time more than 30 days after application of the methacrylate.

It is to be noted again that this material is neither an adherent nor a glue. It forms only a rigid external casing for the aneurysm (Fig. 3) and causes minimal, if any, thickening of the adventitia (Fig. 4).

SUMMARY

A specific method for the prevention of intracranial haemorrhage from cerebral aneurysms is again presented and its use suggested. The methacrylate compound is a relatively non-irritating reinforcement for the weakened vessel-aneurysm complex, maintaining vascular patency and preventing possible recurrent haemorrhage due to faulty clip or ligature application or migration.

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